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EFFECT OF ORGANO-MINERAL AND ORGANIC FERTILIZATION ON THE PRODUCTIVITY OF COMMON WHEAT (*TRITICUM AESTIVUM* L.)

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Abstract

The object of the field experiment was winter bread wheat grown under basic fertilization with organic fertilizers. Against the background of different levels of nitrogen top-dressing in combination with other major agronomic factors, changes in grain yield and its main components were monitored over a three-year period. The objective of the study was to analyze the effects on productivity of fertilizers with an organic composition compared to the mineral fertilizer DAP. The field experiment investigated three main agronomic factors expected to influence grain yield and its components: fertilizer type with mineral (DAP), organo-mineral (Sonar), and fully organic composition (Italpollina); three levels of nitrogen fertilization during vegetation (N50, N100, and N150); and three crop sowing densities: 450, 550, and 650 viable seeds m^{-2}. Variation in all studied traits was mainly due to differences in seasonal conditions (D), followed by fertilizer type (A), nitrogen rate (B), and sowing density (C). Interactions between factors were significant only for $(A \times B)$ and $(A \times D)$ for all traits, and for $(A \times B \times D)$ only for grain yield and number of productive tillers. Fertilizers containing organic matter showed a similar or stronger effect on grain yield and its components compared to the mineral fertilizer DAP under varying seasonal conditions. Fertilization with Italpollina resulted in grain yield comparable to the control (DAP), whereas the application of Sonar led to higher grain yield. The maximum achievable grain yield was obtained at the intermediate nitrogen rate (300 kg ha^{-1}) and a sowing density of 550 seeds m^{-2}, due to the most favourable balance among productivity components.

Key words: wheat, fertilization, organo-mineral fertilizers, productivity

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Introduction. Long-term fertilization predominantly with mineral fertilizers over the last 50 years has led to a drastic reduction in soil organic matter [1–3] and other strongly negative effects on soil properties [4,5]. On the other hand, the use of compound fertilizers (NPK) has increased because they have demonstrated advantages over fertilizers containing a single macronutrient. The application of organic fertilizers, although beneficial for crops, remains very limited and is mainly associated with organic production of vegetables and fruits, where their use is mandatory [6].

In recent years, the cultivation of cereal crops has seen the introduction of various solid or liquid fertilizers of organic origin [7,8]. In their efforts to increase yield or mitigate stress on crops, producers have turned to these products, as a wider selection is now available [9, 10]. Organic fertilizers were not widely used in the past mainly because they were scarcely available on the market, except for products related to vermicompost (California red worms) and some peat-based products.

Scientific and technological progress has led to the production of a new broad range of fertilizers, including the so-called organo-mineral fertilizers (OMF) [11, 12]. These fertilizers can serve as suitable inputs for sustainable agriculture because they promote slow and prolonged nutrient release throughout the growing season, resulting in higher nutrient use efficiency and improved soil moisture retention.

At present, several types of organic fertilizers are available in the country, but their effects on wheat plants are still poorly understood [13, 14]. Among the organic products studied so far, solid organic and organo-mineral fertilizers are the most investigated [13, 17], although scientific information on their effects on cereals remains limited [7, 16]. How would these fertilizers affect wheat when applied within the framework of modern agronomic practices? Would they provide advantages for the crop, soil, and agricultural land ecology, as suggested by some studies [10,18,19]? These questions require answers through systematic and comprehensive research using established scientific methods and approaches.

Therefore, the objective of the present study was to investigate the effects of organic-origin products on wheat, both individually and in combination with major agronomic factors influencing grain yield.

Material and methods. The study was organized as a multifactorial field experiment investigating several key technological factors: fertilizer type (A = DAP, 200 kg ha^{-1}, Sonar, 200 kg ha^{-1}, and Italpollina, 400 kg ha^{-1}), nitrogen top-dressing rate (B = N50, N100, and N150 kg ha^{-1} active substance), and sowing density (C = 450, 550, and 650 number of viable seeds m^{-2}), while seasonal conditions were considered a random environmental factor (D = 2021, 2022, and 2023). The experiment was conducted under the soil and climatic conditions of Dobrudzha Agricultural Institute, General Toshevo, Dobrich region.

The field experiment involved the cultivation of the model wheat cultivar ABC Kolino, following sunflower as the preceding crop. Each combination of factors was established in plots with a harvested area of 8.5 m^2 and four replications. A randomized block design was used to allow appropriate statistical analysis of all productivity traits under study.

To ensure uniform growing conditions, plant protection practices were applied to eliminate potential effects of weeds and diseases. Sowing was performed within the optimal period (1–10 October) each year. Seeds were prepared and treated with a fungicide (Rancona). All other agronomic practices during vegetation followed the specific methodology to ensure objective comparison among factors. Di-ammonium phosphate (DAP), a widely used fertilizer for basal autumn fertilization, was adopted as the standard control treatment.

In relation to the study objective, the following quantitative traits were analyzed: grain yield (GY, t ha^{-1}), number of productive tillers per m^2 (NPT), thousand grain weight (TGW, g) and number of grains per spike (NGS). All traits were determined from crop samples taken from 0.25 m^2 in each of the four replications per treatment. Statistical analyses were conducted using IBM SPSS Statistics 23 and Statgraphics Centurion 18.

Results and discussion. The effects of the studied factors on all traits were highly significant (Table 1). Exceptions were observed for the non-significant effects of fertilizer type on the number of grains per spike (NGS) and sowing den-

Table 1

Analysis of variances (Mean Square) of the quantitative traits by the main factors of the experiment

Source of variation	df	Mean Square + Significance[1]			
		GY	NPT	TGW	NGS
A	2	1.443***	61689.498***	112.296***	40.323 ns
B	2	55.064***	208551.029***	706.203***	1110.321***
C	2	2.795***	320138.48***	8.082 ns	1251.03***
D	2	1628.496***	4762957.152***	3406.414***	3215.468***
A × B	4	2.638***	8659.004***	10.952***	88.363***
A × C	4	0.303 ns	564.313 ns	1.846 ns	5.292 ns
A × D	4	22.568***	36169.498***	108.239***	688.593***
A × B × C	8	0.119 ns	1351.52 ns	4.105 ns	10.336 ns
A × B × D	8	1.591***	10525.486***	19.661 ns	19.671 ns
A × C × D	8	0.304 ns	2997.57 ns	6.601 ns	19.924 ns
A × B × C × D	16	0.23 ns	1309.70 ns	4.205 ns	14.353 ns
Error	891	0.331	2068.332	4.52	19.77

GY – Grain yield, t ha^{-1}; NPT – Number of productive tillers; TGW – Thousand grain weight, g; NGS – Number of grains per spike; [1] – by p-value at $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$, ns – not significant, A = Fertilizer type, B = Nitrogen rate, C = Seed density, D = Season environment, df = degrees of freedom

sity on thousand grain weight (TGW). Only some factors interacted significantly across all traits, namely fertilizer type × nitrogen rate (A × B) and fertilizer type × season (A × D). The three-way interaction A × B × D was significant only for grain yield (GY) and number of productive tillers (NPT). No four-way interaction was detected for any of the traits.

Mean square values for the seasonal factor were the highest for all traits, followed by fertilizer type and nitrogen rate. Variance analysis confirmed that it was appropriate to examine the effects of individual factors and their combinations on the main productivity components.

The comparison of factor levels provides rich information for analysis (Table 2). Seasonal growing conditions (D) resulted in significant differences among traits. Particularly pronounced differences were observed for nitrogen fertilization levels (B), showing a parallel increase in trait values with increasing nitrogen rates. A similar trend was observed for sowing density, with the highest values obtained at the intermediate density of 550 seeds m^{-2}.

No significant effects of fertilizer type on NGS or of sowing density on TGW were detected. The organo-mineral fertilizer Sonar induced a significant positive

Table 2

Differences in the means of the quantitative traits by the main factors of the experiment

Main factors	GY	NPT	TGW	NGS
Fertilizer type				
DAP[1]	8.09 a	533 a	43.1 a	34.1 a
Italpollina	8.09 a	518 a	44.3 c	34.4 a
Sonar	8.21 b	545 b	43.6 b	34.7 a
Nitrogen rate (kg ha^{-1})				
N50	7.67 a	505 a	45.2 c	32.5 a
N100	8.24 b	535 b	43.6 b	34.5 b
N150	8.47 c	556 c	42.3 a	36.2 c
Season environment				
2021	10.32 c	644 c	46.7 c	31.9 a
2022	8.23 b	550 b	40.2 a	37.9 c
2023	5.84 a	403 a	44.1 b	33.4 b
Seed density (Number of seeds m^{-2})				
450	8.04 a	500 a	43.5 a	36.3 c
550	8.22 c	533 c	43.8 a	34.5 b
650	8.13 b	563 b	43.7 a	32.4 a

[1]Di Ammonium Phosphate; Means followed by the same letter(s) in a column for each variable are not significantly different based on Duncan's post hoc test, at $\alpha = 0.05$

effect on most traits (except NGS), with values significantly higher than those of the other fertilizers. Italpollina showed a significant advantage over DAP only for thousand grain weight.

Two main factors, apart from season, substantially influenced trait magnitude against the background of fertilizer type: nitrogen rate and sowing density. Their interaction with fertilizer type provides information on optimal technological variants for achieving high and stable yields across seasons (Fig. 1).

The highest nitrogen rate (150 kg ha^{-1}) resulted in the strongest increase in most traits, except TGW, which showed the lowest values at this level. Notably, Italpollina produced the highest trait values at the lowest nitrogen level (50 kg ha^{-1}), except for NPT. For NGS at the highest nitrogen rate, no significant differences among fertilizers were observed.

Trait performance under different sowing densities showed marked differences (Fig. 2). For NPT and NGS, differences among densities were significant regardless of fertilizer type, with the highest values at the lowest density. No differences in TGW were observed among densities. For grain yield, significant differences were found between the lowest and higher densities, confirming 550 viable seeds m^{-2} as the optimal density for this experimental setup.

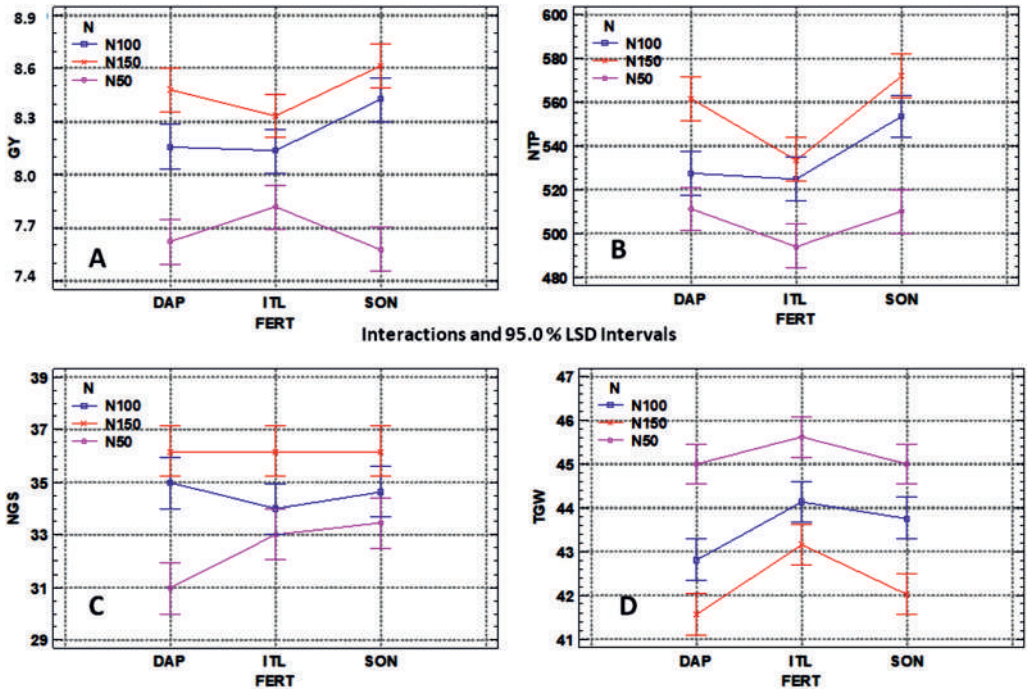

Fig. 1. Two-factor conditional comparisons for the interaction of *Fert* × *N* for traits GY (**A**), NPT (**B**), NGS (**C**) and TGW (**D**)

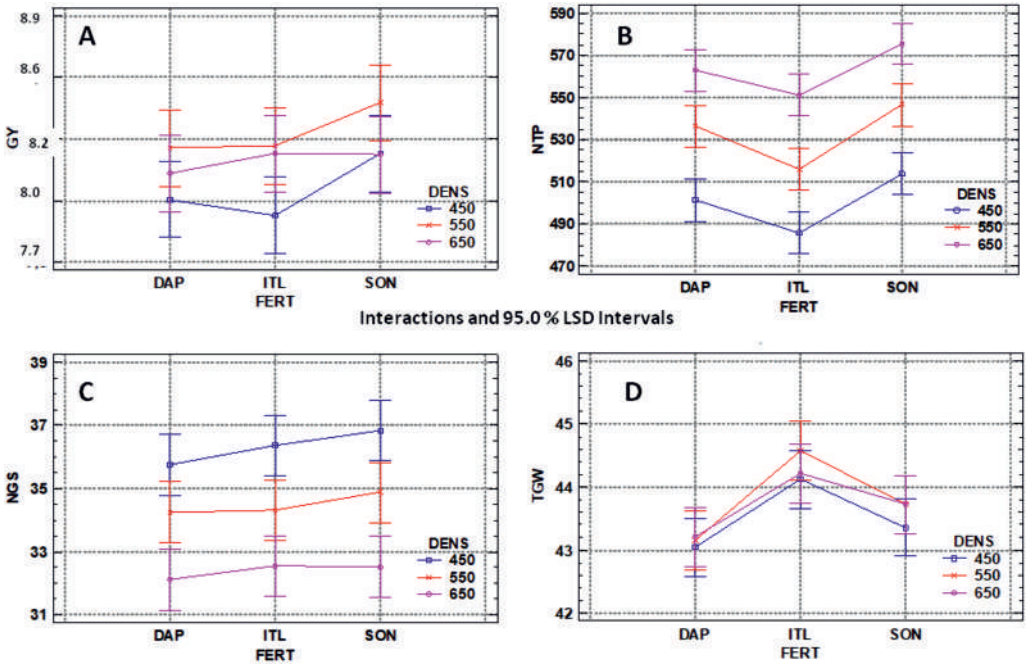

Fig. 2. Two-factor conditional comparisons for the interaction *Fert* × Dens for traits GY (**A**), NPT (**B**), NGS (**C**) and TGW (**D**)

Fertilization of wheat with organic fertilizers can be an alternative to exclusive mineral fertilization. Results clearly indicate that basal fertilization with organic fertilizers combined with moderate nitrogen top-dressing (100 kg ha^{-1} active substance) can achieve high grain yields due to an optimal balance among productivity components. Similar results were reported by Carciochi et al. [17], who found 13% higher wheat yields with organic fertilizers compared to mineral ones. Therefore, it is recommended that mineral fertilizers be replaced by organic fertilizers for at least 25% of the crop's macronutrient requirements [15].

The most pronounced differences were observed for TGW across the three nitrogen levels and all fertilizer types. These results are largely consistent with those reported by Burak and Sakrabani [11], Tsenov et al. [7, 15], with the exception that the fully organic fertilizer Italpollina and DAP showed comparable mean values for GY and NPT, whereas only Sonar resulted in significantly higher values. Overall, the fertilizers proved to be more effective at higher nitrogen rates, while for all traits except TGW no significant differences were observed between nitrogen applications of 100 and 150 kg ha^{-1}.

Trait responses to different sowing densities showed clearly differentiated patterns (Fig. 2). For the number of productive tillers and the number of grains per spike, statistically significant differences among the three sowing densities were observed regardless of fertilizer type, with the highest values recorded at the lowest

density and vice versa. No significant differences in TGW were detected among sowing densities for any fertilizer. For grain yield, significant differences were found between the lowest density (450 seeds m^{-2}) and the two higher densities (550 and 650 seeds m^{-2}), once again indicating that 550 seeds m^{-2} represents the optimal sowing density for the present experimental design. However, at this density the number of grains per spike was lower than that observed at the highest density, particularly under fertilization with organic-based products.

Fertilization of wheat with organic fertilizers may represent a viable alternative to exclusive reliance on mineral fertilizers. This conclusion is supported by results clearly demonstrating that basal fertilization with organic fertilizers combined with moderate nitrogen top-dressing (100 kg ha^{-1} active substance) can produce high grain yields. These yields result from an optimal sowing density that promotes a favourable balance among yield components. Similar findings were reported by Carciochi et al. [17], who observed 13% higher wheat yields following the application of organic fertilizers compared with mineral fertilizers. Consequently, it has been recommended that mineral fertilizers be replaced by organic fertilizers for at least 25% of the crop's macronutrient requirements [15].

Conclusions. Seasonal environmental conditions exert the strongest influence on grain yield and its components compared with the studied agronomic factors. Although the direct effects of each main factor are statistically significant, their individual contributions are relatively small for all traits. In contrast, interactions among the main factors are relatively stronger than their individual effects, ranking second in importance after seasonal conditions.

Each level of the main agronomic factors affects trait expression, with particularly pronounced responses observed with increasing nitrogen rates and depending on fertilizer type. The demonstrated higher positive effect of organic fertilizers on grain yield is mainly attributable to increases in the number of productive tillers and the number of grains per unit area. A sufficiently high grain yield can be achieved at the intermediate nitrogen rate (100 kg ha^{-1}), owing to the most favourable balance among yield components at this level.

Fertilizers containing organic matter (Sonar and Italpollina) exert comparable or even stronger positive effects on grain yield and its components than the mineral fertilizer DAP under conditions of pronounced meteorological anomalies.

REFERENCES

[1] Filcheva E. (2015) Characteristics of Soil Organic Matter of Bulgarian Soils, Lap Lambert Academic Publishing, 177 pp, ISBN 978-3-659-51204-9.

[2] Nankova M. (2012) Long-term mineral fertilization and soil fertility. In: Agricultural Science (ed. Dr. Godwin Aflakpui), Chapter 6, InTech, 97–118.

[3] Nankova M. (2018) Relationships between haplic chernozems mineralization ability and soil organic matter composition as a result from long-term systematic mineral fertilization, Soil Scientists Society behalf V. V. Dokuchaev, Working Group of

Chernozem investigation Rostov-on-Don–Taganrog, Publishing House of Southern Federal University, 322–331.
[4] Hristov B., E. Filcheva, P. Ivanov (2016) Organic matter content and composition of soils with stagnic properties from Bulgaria, Bulg. J. Soil Sci., **1**(1), 26–32.
[5] Nankova M. (2014) Soil organic matter – the function of crop rotation, tillage and mineral fertilization. In: Soil Organic Matter and Soil Fertility in Bulgaria (ed. M. Theoharov et al.), Bulgarian Society for Humic Substances, 240–261, ISBN 978-619-90189-1-0, (in Bulgarian).
[6] Milev G., N. Nankov, I. Iliev et al. (2014) Growing wheat (*Trititcum aestivum* L.) by the methods of organic agriculture under the conditions of Dobrudzha region, Bulgaria, Turk. J. Agric. Nat. Sci., Special Issue **1**, 849–857.
[7] Tsenov N., M. Nankova, T. Gubatov (2021) Research of the effect of organic fertilizers on common wheat (*Triticum aestivum* L.) grain yield, Bulg. J. Crop Sci., **58**(3), 3–13, (in Bulgarian).
[8] Petkova Z., I. Gerasimova, M. Nazarkov (2025) Results of testing the effect of new liquid complex fertilizers in a field experiment with maize, Bulg. J. Crop Sci., **62**(2), 34–43, (in Bulgarian).
[9] Chojnacka K., J. Baltrusaitis (2025) Organo-mineral fertilizers for sustainable agriculture, Sustain. Sci. Technol., **2**(2), 022001, https://doi.org/10.1088/2977-3504/adc0a8.
[10] Sánchez-Méndez S., L. Orden, S. Franco-Luesma et al. (2025) Agronomic and environmental assessment of a new fertilization strategy using pelleted organo-mineral fertilizers for wheat production in Mediterranean agricultural soils, Sci. Rep., **15**(1), 36866, https://doi.org/10.1038/s41598-025-20818-9.
[11] Burak E., R. Sakrabani (2023) Novel carbon capture-based organo-mineral fertilizers show comparable yields and impacts on soil health to mineral fertilizer across two cereal crop field trials in Eastern England, Field Crops Res., **302**, 109043, https://doi.org/10.1016/j.fcr.2023.109043.
[12] Nankova M., V. Savov, K. Chakalov (2016) Effect of a humic preparation with immobilized enzyme systems of beneficial microorganisms on the productivity of *T. aestivum* L. cultivars under low-input nutrition regime. In: Book of Abstracts and Proceeding, 3rd National Humic Substance Congress with International Participation, November 3–5, Konya, Turkey, 124–136.
[13] Thomas C. L., G. E. Acquah, A. P. Whitmore et al. (2019) The effect of different organic fertilizers on yield and soil and crop nutrient concentrations, Agronomy, **9**(12), 776, 1–25, https://doi.org/10.3390/agronomy9120776.
[14] Apaeva N. N., S. G. Manishkin, L. V. Kudryashova, A. M. Yamalieva (2020) An innovative approach to the use of the granulated organic fertilizers based on bird droppings on crops of spring wheat, IOP Conf. Ser.: Earth Environ. Sci., **421**, 022062, https://doi.org/10.1088/1755-1315/421/2/022062.
[15] Tsenov N., M. Nankova, T. Gubatov (2021) Analysis of productivity related traits of common wheat (*Triticum aestivum* L.) using organic fertilizers, Bulg. J. Crop Sci., **58**(3), 14–27, (in Bulgarian).
[16] Bo P., Q. He, Y. Lan et al. (2025) Reducing mineral fertilizer can improve the soil quality and increase the wheat yield and nutrient utilization efficiency: the fertilizing effect of organic–inorganic compound fertilizers, Agriculture, **15**(12), 1294, https://doi.org/10.3390/agriculture15121294.

[17] Carciochi W. D., J. L. Ferrari, L. Orden, J. A. Galantini (2024) Pelletized organomineral vs. inorganic nitrogen and phosphorus fertilizers: impact on wheat nutritional status, productivity, and grain quality, J. Soil Sci. Plant Nutr., **24**(4), 7361–7372, https://doi.org/10.1007/s42729-024-02045-9.
[18] Uddin K., B. K. Saha, V. N. Wong, A. F. Patti (2025) Organo-mineral fertilizer to sustain soil health and crop yield for reducing environmental impact: A comprehensive review, Eur. J. Agron., **162**, 127433, https://doi.org/10.1016/j.eja.2024.127433.
[19] Ejigu D., R. Pushpalatha, S. K. Jayaprakash et al. (2024) Integrated fertilizers for sustainable wheat production to improve food security – a comprehensive review, J. Plant Nutr. Soil Sci., **188**(1), 5–16, https://doi.org/10.1002/jpln.202400213.

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